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Locating and estimating the extent of Delmarva fox squirrel habitat using an airborne LiDAR profiler

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Abstract

Two thousand five hundred thirty-nine kilometers of airborne laser profiling and videography data were acquired over the state of Delaware during the summer of 2000. The laser ranging measurements and video from approximately one-half of that data set (1304 km) were analyzed to identify and locate forested sites that might potentially support populations of Delmarva fox squirrel (DFS, *Sciurus niger cinereus*). The DFS is an endangered species previously endemic to tall, dense, mature forests with open understories on the Eastern Shore of the Chesapeake Bay. The airborne LiDAR employed in this study can measure forest canopy height and canopy closure, but cannot measure or infer understory canopy conditions. This airborne LiDAR profiler, then, must be viewed as a tool that identifies and locates potential, not actual, habitat. Fifty-three potentially suitable DFS sites were identified in the 1304 km of flight transect data. Each of the 53 sites met the following criteria according to the LiDAR and video record: (1) at least 120 m of contiguous forest; (2) an average canopy height >20 m; (3) an average canopy closure of >80%; and (4) no roofs, impervious surface (e.g., asphalt, concrete), and/or open water anywhere along the 120 m length of the laser segment. Thirty-two of the 53 sites were visited on the ground and measurements taken for a DFS habitat suitability model. Seventy-eight percent of the sites (25 of 32) were judged by the model to be suited to supporting a DFS population. All of the LiDAR flight data, 2539 km, were analyzed to estimate county and statewide forest area in different height/canopy closure classes. Approximately 3.3% of Delaware (17,137 ha) supports forest over 20 m tall with crown closures exceeding 80%; the corresponding county percentages are Newcastle County—6.1% (6823 ha), Kent County—2.2% (3431 ha), and Sussex County—2.7% (6883 ha). Estimates of average within-patch crossing distance and average between-patch distances are reported, by county, and for the state. Study results indicate that: 1) systematic airborne LiDAR data can be used to screen extensive areas to locate potential DFS habitat; 2) 78% of sites meeting certain minimum length, height, and canopy closure criteria will support DFS populations, according to a habitat suitability model; 3) airborne LiDAR can be used to calculate county and state acreage estimates of potential habitat, and 4) the linear transect data can be used to calculate patch statistics. The authors suggest that the systematic county and state flight lines can be revisited at intervals to monitor changes to the areal extent of potential habitat over time.

Keywords: Habitat mapping; Profiling LiDAR; Airborne laser

1. Introduction

The Delmarva fox squirrel (DFS, *Sciurus niger cinereus*), an endangered species on the Delmarva Peninsula, was endemic to mature, closed-canopy forest stands with open understories and plentiful mast production (Bendel & Therres, 1994; Dueser et al., 1988). Reduction in available area and landscape fragmentation has reduced the amount of mature forest needed to support viable populations to the point where the DFS was placed on the endangered species list in 1967. Range constriction was fundamental to listing the DFS as endangered, and documentation and protection of available habitat are considered top priorities to facilitate recovery. The need to assess and monitor DFS habitat rapidly over large areas (e.g. states and regions) has been identified in both the 1993 Delmarva fox squirrel Recovery Plan (USFWS, 1993) and the status and recovery plan update for this species (USFWS, 2003).

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Airborne lasers (i.e., airborne LiDAR) may be used to remotely measure forest structure, specifically forest canopy height, height variability (Næsset, 1997; Nelson et al., 1988; Nilsson, 1996), percent canopy cover (Ritchie et al., 1993), and vertical vegetation structure (Blair & Hoften, 1999; Blair et al., 1999, Lefsky et al., 2002). An airborne laser profiler acquires precise ranging measurements from aircraft to targets directly beneath the aircraft along flight lines tens or hundreds of kilometers long. The distance between sequential ranging measurements is project-specific and adjustable, but typical post spacing is on the order of 0.1–0.5 m. The sequential ranging measurements provide a view similar to a knife slice across the terrain; when that knife slice is viewed from the side, a profile of the landscape emerges (Fig. 1). The laser profiling data can be treated as a linear sample (Andrianarivo, 1993; DeVries, 1986; Kaiser, 1983) and used to develop estimates of forest and nonforest resources. In conjunction with a land-cover GIS and/or simply by defining certain height classes as forest, the airborne laser profiling transects can be parsed into forest and nonforest segments. The LiDAR data can be further parsed into segments with particular height (e.g., forests >20 m tall) and land cover (e.g., roofs, asphalt/concrete, open water) characteristics if coincident videography is interpreted to delineate the impervious surface and water crossings.

Airborne LIDAR profiling measurements were acquired over the entire state of Delaware during the summer of 2000 using a small, relatively inexpensive, transportable airborne laser profiling system (Nelson et al., 2003a). This first-return laser senses top-of-canopy characteristics; essentially no information is available concerning sub-canopy layers and ground cover. The DFS prefers tall, mature stands with plentiful mast and an open understory. Given that the LiDAR data can identify tall stands but contains no information on tree species (e.g., mast production) or ground cover conditions, the LiDAR must be viewed as a screening tool that can be used to identify potential habitat. Ground visits are needed to determine if the tall stands located by the laser profiler would, in fact, support viable DFS populations.

An airborne LiDAR can be used to assess wildlife habitat *if* the quality and/or extent of the habitat is related to the vertical structure of forest or range. The overall objective of this study is to assess the utility of an inexpensive, airborne profiling LiDAR for DFS habitat delineation and measurement. The study has a number of specific sub-objectives: (1) Determine, by field visit, the proportion of these LIDAR-detected sites that actually provide suitable DFS habitat, where habitat suitability is assessed using a habitat suitability model. (2) Estimate the regional extent of potential DFS habitat, by county, for the state of Delaware. (3) Calculate landscape-level patch statistics, by county, for the state. The authors suggest that, once the proportion of actual to potential habitat is known, then regional acreage estimates of DFS habitat loss or gain can be estimated quickly by analyzing laser data acquisitions at time 0, time 1, time 2, etc. With habitat loss, development, timber harvest, and long-term sea level rise considered to be primary threats to DFS recovery, this technique has the potential to serve as a quantitative, rigorous, and time-efficient wildlife management tool.

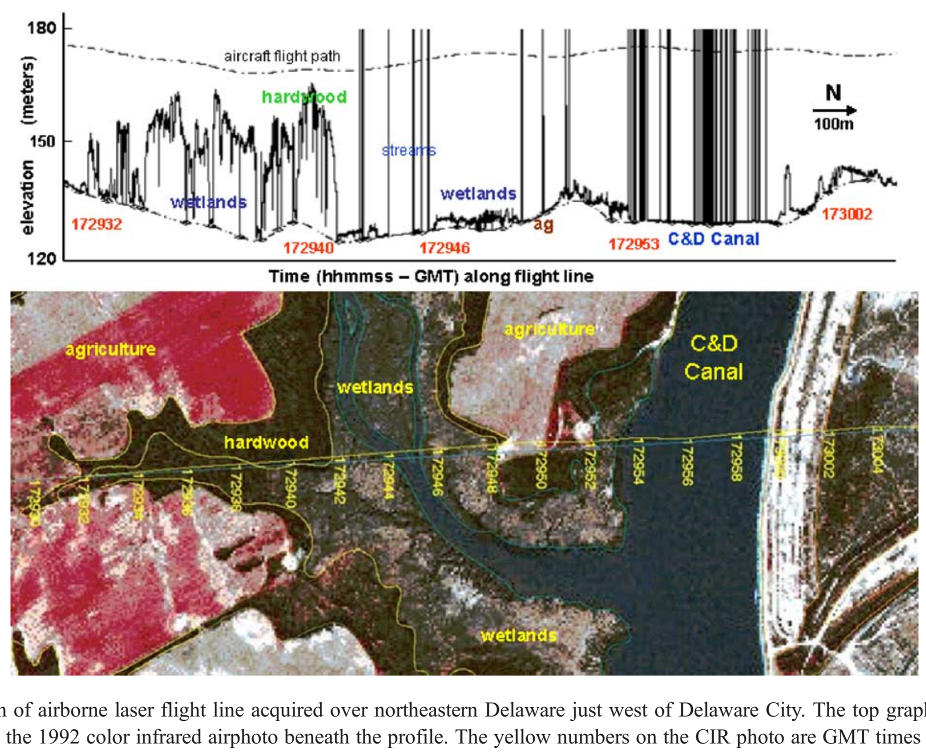

Fig. 1. A 1.6 km section of airborne laser flight line acquired over northeastern Delaware just west of Delaware City. The top graph is the airborne LiDAR profile corresponding to the 1992 color infrared airphoto beneath the profile. The yellow numbers on the CIR photo are GMT times associated with the laser aircraft overflight. Corresponding times are listed in red on the profile. The tall, flat-topped returns noted on the LiDAR profile represent individual laser shots where the return strength of the reflected laser pulse equaled zero. The laser transmits pulses in the near infrared (0.905 μm), and water tends to absorb these near-infrared pulses.